

**UNITED STATES MARINE CORPS**  
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**STUDENT HANDOUT**

**REVERSE OSMOSIS WATER PURIFICATION UNIT**

1. LEARNING OBJECTIVES:

a. Terminal learning objectives:

(1) Provided a Reverse Osmosis Water Purification (ROWPU), earplugs, a water source, fuel, oil, a power source, and references, operate the unit in accordance with TM-08580A-10/1. (1171.02.04)

(2) Provided a Reverse Osmosis Water Purification Unit (ROWPU), earplugs, a water source, a power source, and references, perform preventive maintenance in accordance with TM-08580A-10/1. (1171.04.04)

b. Enabling learning objectives:

(1) Given the necessary equipment, a water source, tools and materials, without the aid of references, set up the unit in accordance with TM-08580A-10/1. (1171.02.04a)

(2) Given the necessary equipment, a water source, tools and materials, without the aid of references, start the unit in accordance with TM -08580A-10/1. (1171.02.04b)

(3) Given the necessary equipment, a water source, tools and materials, without the aid of references, conduct operators maintenance in accordance with TM-08580A-10/1. (1171.04.04a)

(4) Given the necessary equipment, and materials, complete the documents in accordance with FM 10-5-1. (1171.02.04c)

(5) Given the necessary equipment, a water source, tools and materials, without the aid of references, shut down the unit In accordance with TM-08580A-10/1. (1171.02.04d)

(6) Given the necessary equipment, a water source, tools and materials, without the aid of references, disassemble the unit in accordance with TM-08580A-10/1. (1171.02.04e)

(7) Given the necessary equipment, a water source, tools and materials, without the aid of references, install NBC cartridges to the unit the unit in accordance with TM-08580A-10/1. (1171.02.04f)

(8) Given the necessary equipment, a water source, tools and materials, without the aid of references, backwash the unit in accordance with TM-08580A-10/1. (1171.04.04b)

(9) Given the necessary equipment, a water source, tools and materials, without the aid of references, conduct and element cleaning to the unit in accordance with TM-08580A-10/1. (1171.04.04c)

(10) Given the necessary equipment, a water source, tools and materials, without the aid of references, conduct and element replacement to the unit in accordance with TM-08580A-10/1. (1171.04.04d)

(11) Given the necessary equipment, a water source, tools and materials, without the aid of references, replace the cartridge filters on the unit in accordance with TM-08580A-10/1. (1171.04.04e)

## BODY

### 1. Characteristics and capabilities:

a. Osmosis is the spontaneous flow of a liquid of low concentration through a semipermeable membrane, a material that only certain molecules can readily pass, into a solution of higher concentration that tends to equalize the levels on both sides of the membrane. The process of both sides equalizing is referred to as the osmotic effect. Reverse Osmosis is water flowing at high pressure, through a semipermeable membrane in the opposite direction from Osmosis. The result is water with a high concentration to water with a low concentration of molecules other than water.

b. The Reverse Osmosis Water Purification Unit (ROWPU) is a skid mounted, mobile, or air transportable unit capable of purifying fresh, brackish, and salt water at a rate of 600 gallons per hour.

c. The unit is configured in a frame that measures 5.6' H x 6.9' W x 9.5' L, weighs approximately 7300 lbs

d. The unit requires a 22 kilowatt power source.

e. The unit is designed to operate for 20 continuous hours a day.

f. The ROWPU requires 2 personnel for operation.

### 2. Description of components:

a. Raw Water Pump: Water is delivered to the unit by the raw water pump. There are two raw water pumps and they are both:

(1) Centrifugal

(2) Self-priming after the initial prime

(3) Rated at 30 gpm with a 105 ft. head

(4) Powered by 2 HP electric motor

b. Multimedia Filter: When the raw water enters the ROWPU it goes through its first cycle of filtration in the multimedia filter. Water enters the filter through the top inlet pipe and passes through various layers of media to the bottom of the filter. Once on the bottom, the partially purified water enters the perforated pipes and exits the outlet pipe on the bottom of the filter. The media consists of: 3" of garnet, 12" of filtered sand, 15" of coal and 2" of plastic material weighing 805 lbs which sits on top of 425 lbs of bedding. The bedding consist of gravel: fine through medium grades.

c. Booster Pump: The booster pump transfers the water from the multimedia filter to the cartridge filter. In doing so, it equalizes the flow of water pressure through the multimedia filter. The pump is:

(1) Centrifugal

(2) Rated at 30 gpm with a 50 ft. head

(3) Powered by a 1 HP electric motor

d. Cartridge Filter: The cartridge filter consists of an upper and lower compartment. The upper compartment houses eight 40 inch long disposable fiber cartridges that provide a secondary stage of filtration by removing any suspended matter in the water missed by the multimedia filter. This filtered water is then collected in the lower compartment where it will be suctioned by the R.O. pump.

e. R.O. Pump: Picks up the water from the lower compartment of the cartridge filter and pressurizes it. The R.O. pump is a high pressure pump with:

(1) Positive displacement plungers (5 pistons); 3 pistons on the Charlie Model.

(2) Rated at 51 gpm with a 980 psi head.

(3) Driven by five V-belts from a 20 HP electric motor which turns counterclockwise.

**NOTE: The R.O. pump has adjustable low pressure and high pressure switches, located behind the control panel that activates when the R.O. pump has less than 10 psi inlet pressure or discharge pressure exceeds 1250 psi. When activated, either switch will shut off the R.O. pump.**

f. Pulse Dampener: The R.O. pump pushes the water through the pulse dampener which reduces pulsation in the water caused by the pistons of R.O. pump. There are (4) baffles inside the pulse dampener designed to reduce shock. From the pulse dampener, the water exits the vent vessel line (a bypass to the R.O. vessels) until the vent

vessels valve is closed. Once closed, the water is then redirected to the R.O. vessels.

g. R.O. Vessels: There are four R.O. vessels, each housing two R.O. elements. These elements are joined in the middle by an interconnector (plastic couplings). There are also end connectors that join the end caps to the outside of the elements.

h. R.O. Elements (Spiral Wound): When water enters the R.O. vessels, it is then on it's final stage of filtration. Each element has a brine seal that opens up against the water flow channeling the water through the R.O. element. As the water enters the elements, it works it's way down the spiral membranes where molecule separation occurs. In it's final stage the water enters the product water tube located in the center and exits the unit as product water. The remaining feed fluid (brine) continues to flow through the other end of the element then enters the next element until the process repeats itself through all eight elements. It then leaves the R.O. vessels as brine water. These elements are designed to reject a minimum of 98.5% of salt from the water and about 99% of all organic materials in the water. The two types of elements used are Filmtec and Fluid Systems.

**NOTE: Chlorine will destroy membranes in the R.O. elements rendering the R.O. elements unserviceable.**

i. Distribution Pump: The product water is distributed from the product water tank by using a distribution pump. It is rated at 30 GPM.

j. Backwash Pump: The Backwash Pump is rated at 120 GPM and is used to backwash the multimedia filter. A strainer assembly is attached to the discharge end of the pump to filter out any particles in the backwash tank.

k. Chemical Feed Pump: The R.O. unit uses several chemicals to aid in production of water. There are four chemical feed pumps each rated at 3.17 gals/hr and powered by a 1/3 HP electric motor. They are:

(1) Chlorine Feed Pump: Feeds diluted chlorine to product water to kill bacteria so that water in storage tanks remain potable.

(2) Polymer Feed Pump: Feeds diluted polymer (polyelectrolyte) solution to raw water to coagulate suspended matter into groups large enough to be removed by the multimedia filter.

(3) Sodium Hex Feed Pump: Feeds diluted sodium hex solution (sodium hexametaphosphate) to prevent calcium scaling in the pipes of the ROWPU.

(4) Citric Acid Feed Pump: Feeds diluted acid (tricarboxylic acid) to the raw water, to lower the pH and strengthen the membranes elements for better rejection.

1. Circuit Breakers: Circuit breakers are located in the junction box. They are used to shut off power to pump motors, utility outlets, and backwash timer if there is an electrical malfunction in the circuit.

m. Junction Box: Junction box is located on the right side of the control panel. It is used for attaching pump cords and has two utility outlets.

n. Control Panel: The control panel consists of various gauges, valves, lights, switches, and hose connections.

(1) Multimedia Filter Gauge: Shows the pressure, in pounds per square inch, of the multimedia filter and indicates when the filter is dirty.

(2) Raw Water Flow Meter: Measures, in gallons per minute, the amount of water drawn in by the raw water pumps and fed into the ROWPU.

(3) Backwash Gauge: Measures, in gallons per minute, the amount of water flowing into the multimedia filter from the backwash pump during the backwash cycle.

(4) R.O. Vessels Gauge: Shows discharge pressure, in pounds per square inch, of water flowing through the R.O. vessels during normal operation.

(5) R.O. Pressure PSI Gauge: Shows discharge pressure, in pounds per square inch, of the R.O. pump. Gauge reading depends on setting of the regulated product flow valve.

(6) Brine Flow Meter: Measures, in gallons per minute, the amount of brine flow exiting the R.O. in gallons per minute.

(7) Product Water Flow Gauge: Measures, in gallons per minute, the amount of drinking water put out by the ROWPU.

(8) Cartridge Filter Gauge: Shows the pressure, in pounds per square inch, of the cartridge filter and indicates when the filter is dirty.

(9) Waste Outlet: Connection for wastewater hose for wastewater being discharged from the multimedia filter during the backwash cycle.

(10) Backwash Water Inlet: Connection for backwash pump discharge hose into unit for backwashing the multimedia filter.

(11) Raw Water Inlet: Connection for raw water pump discharge hose linking the raw water pump to the ROWPU.

(12) Product Water Outlet: Connection for product water hose from the ROWPU to the product water tank.

(13) Vent Vessels Outlet: Connection for discharge hose used to fill up the backwash tank.

(14) Brine Outlet: Connection for discharge hose from the ROWPU out to the drainage ditch.

(15) Vent, Cartridge Filter: Relieves air from cartridge filter.

(16) Vent, Pulse Dampener: Relieves air from pulse dampener.

(17) Vent, Multimedia Filter: Relieves air from multimedia filter.

(18) Backwash Valve: Has two positions, NORMAL and BACKWASH. In the normal position, the valve closes the backwash inlet and allows raw water to flow into the multimedia filter. In backwash, the raw water inlet is closed and allows the water from the backwash pump to flow to the multimedia filter.

(19) Regulate Product Flow Valve: Valve used to regulate the amount of product water exiting the ROWPU. This valve also decreases the amount of brine flow exiting the ROWPU.

(20) In-Line TDS Monitor: Used to continually monitor product water TDS. Found only on the "Charlie" models.

o. Control Box Assembly: Located on the control panel, it consists of indicator lamps and switches to start, operate, and stop all pumps.

(1) R.O. Pump Low Pressure Indicator Lamp: Lamp that comes on when R.O. pump suction pressure drops below 10 psi. This lamp also indicates that the R.O. pump should have shut off.

(2) R.O. Pump High Pressure Indicator Lamp: Lamp that comes on when R.O. pump discharge pressure is higher than 1250 psi. This lamp also indicates that the R.O. pump should have shut off.

(3) Backwash Pump Indicator Lamp: White lamp comes on when the backwash pump switch is activated.

**NOTE: All indicator lights have a blackout adjustment on them. By turning the lamp cover right or left you can increase or decrease the amount of light showing in the lamp.**

**NOTE: Green lamp indicates that the pump motor starting relay is activated, and does not indicate that the pump is running normally.**

(4) Emergency Stop Switch: When pushed in, this switch shuts off power to all pump motors.

**WARNING, THE EMERGENCY STOP SWITCH SHOULD NOT BE USED TO SHUT OFF THE ROWPU EXCEPT IN EMERGENCY CONDITIONS. TO DO SO CAN CAUSE DAMAGE TO THE EQUIPMENT. PUSH IN EMERGENCY STOP BUTTON ONLY IF ANY OF THE FOLLOWING CONDITIONS EXIST:**

(a) Operators could be injured or the equipment could be damaged if operation of the ROWPU is allowed to continue.

(b) Red high pressure lamp associated with R.O. pump comes on but the unit does not automatically stop.

(c) Yellow low pressure lamp associated with R.O. pump comes on but the unit does not automatically stop.

(d) Some other serious trouble (malfunction) is indicated by noise, vibration, large water leaks, etc.

(e) When backwash pump lamp and backwash pump itself comes on during normal filtering operation.

(f) When high pressure relief valve activates during normal operation.

(g) When rupture disc ruptures during normal operation.

(5) Each of the following switches are used to start, stop, and run their corresponding pumps: R.O. Pump, Booster Pump, Chemical feed pump, Raw Water Pumps 1 and 2. When these switches are activated, a green indicator lamp located above each switch illuminates.

(6) R.O. Pump Reset Switch: Toggle switch used to reset the low or high pressure switch associated with the R.O. pump. This switch must be reset prior to activating the R.O. pump switch.

(7) R.O. Pump JOG Switch: Toggle switch used to check the R.O. pumps rotation for proper power supply connection. This switch may also be used to drain out the R.O. pump when held in 3 to 5 second intervals.

(8) Panel Light Switch: Toggle switch used to turn the panel light on and off.

p. Panel Light: Provides light for the control panel.

q. R.O. Element Cleaning Switch: Used to operate backwash pump during cleaning of the R.O. elements. Switch is located on left side of control panel under a spring-loaded safety guard above the product water outlet.

r. Vent Vessels Valve: Located behind the vent vessel's hose hookup, is used to direct the flow of water from the pulse dampener either to the backwash tank or the RO vessels.

s. Backwash Timer: Contained in a metal box located by the multimedia filter. The timer works in conjunction with the 6-way valve to control the backwash cycle.

t. Chemical Feed Pump Valves: There are four valves used to prime and feed chemicals directly into the unit during normal operation. The valve positions are:

(1) Up for RUN.

(2) Down for PRIME

u. Chemical Feed Pump Controls: Used to control the flow of each chemical. There is one control knob located above each chemical feed pump valve.

v. Vent, Product Water Valve: Located on the top of the product water line, this valve allows air to escape the line when the pipe fills up.

w. Product Water Sample Valves: Located on both ends of each R.O. vessel, these sample valves allow the operator to draw a sample of product water from any of the four vessels to accurately diagnose a malfunctioning element. These valves are found only on the "Charlie" models.

x. Product Water Drain-Cock: Located at the bottom of the product water line, used for draining the product water line on the "Alpha" models only.

y. Drain Valves: Seven drain valves are located at the right rear of the ROWPU. They are used to drain water from the unit during a long shutdown. The drain # 1 cartridge filter is used during filtration to perform a clarity test.

z. Ground Rods: Helps to protect the operator from electrical shock.

aa. Product Water Gallon Meter: Located between the product water manifold and the product water outlet. This meter is only found on the "Charlie" models.

bb. Safety Valves: The ROWPU has two automatic safety valves. The high pressure relief valve and the rupture disc assembly.

(1) The high pressure relief valve is located after the pulse dampener, if R.O. pressure goes above 1100 psi, this valve opens automatically and discharges water through a pipe located between the booster pump and chemical feed pumps.

**NOTE: If this valve activates, immediately open the regulate product flow valve and push in the emergency stop switch. When the pressure drops below 1100 psi the valve will automatically close.**



(2) The rupture disc assembly is located on the discharge end of the R.O pump. The rupture disc is a thin sheet of metal that tears when the R.O. pump discharge pressure exceeds 1425 psi and high pressure switch failed to activate.

**NOTE: If the rupture disc assembly ever activates, open the regulate product flow valve and push in the emergency stop switch. When pressure drops, replace the ruptured disc and notify maintenance to troubleshoot the high pressure relief valve and the high pressure switch.**

cc. Color Coded Pipes: The ROWPU piping is identified by color according to their functions. The function and color are as follows:

- (1) Raw water - Black band
- (2) Backwash waste - Red band
- (3) Filtered water - Yellow band
- (4) Product water - Blue band
- (5) Brine discharge - Purple band

dd. Storage Boxes:

(1) Chemical Chest: Stores a five day supply of chemicals needed to purify water. It also contains several SL-3 components.

(2) Tool Chest: Houses all the toolkits necessary to maintain the unit. It also stores the remaining SL-3 components.

ee. NBC Canisters:

(1) Radiation: Used to absorb radioactive contamination from the product water. This canister is good for only 100 hrs. of filtration at which time it will be tagged and labeled for disposal.

(2) Chemical: Used to absorb chemical agent contamination from the product water. This canister is good for 100 hrs. of filtration at which time it will be tagged and labeled for disposal.

ff. Hoses: The unit is provided with both suction and discharge hoses.

gg. Float: Used to keep strainer from sucking from the bottom of the water source.

3. Set up procedures:

a. Site selection:

(1) Stage the ROWPU within 75 ft. from your water source on firm, level ground.

(2) If a stream or lake is used as the raw water source, stage the ROWPU upstream from the camp.

(3) Adequate cover and concealment.

(4) Sufficient road nets.

(5) Good drainage.

(6) Test water.

(a) Take TDS reading.

(b) Take Chlorine Residual.

b. Installation:

(1) Roll up canvas cover over the ROWPU frame and fasten with tie-back straps.

(2) Remove the two frame cross braces. Release cargo straps.

(3) Remove float and five chemical pails.

(4) Remove nine 1-1/2" suction hoses one 2" suction hose, six 1-1/2" discharge hoses, and three 2" discharge hoses.

(5) Remove the two storage boxes but do not empty them.

(6) Remove chemical container assembly and locate it in front of the chemical feed pump.

(7) Remove raw water, backwash and distribution pumps.

(8) Remove and install raw, backwash and product water tanks.

(9) Install raw water system:

(a) Install a strainer and float at the end of the raw water suction hose connected to pump suction, and drop the discharge hose into the raw water tank.

(b) Connect suction hose and then connect the discharge hose between the pump discharge outlet and raw water inlet connection on the ROWPU.

(c) Connect electrical cables to the junction box.

(10) Install backwash water system:

(a) Install the backwash strainer onto the discharge side of the backwash pump by bolting the strainer bracket to the frame

(b) Connect a 2" gate valve to the bottom of backwash tank. Attach a 2" suction hose from gate valve to the backwash pump. Ensure gate valve is closed.

(c) Connect electrical cable from pump to junction box.

(d) Connect 2" discharge hose from the backwash pump strainer to on the backwash water inlet connection on ROWPU.

(e) Connect 1-1/2" discharge hose from brine outlet on the ROWPU and drop it into the backwash tank.

(11) Connect product water system:

(a) Connect a 1-1/2" suction hose to the product water outlet on the ROWPU. Connect a 1-1/2" discharge hose to the suction hose. Product water hose will lay next to product water tank until the water has been tested.

(b) If using two storage tanks, connect a 1-1/2" suction hose between each tank.

(c) Hook up distribution pump to storage tank.

(d) Connect electrical cable from the distribution pump to the junction box.

(12) Connect waste water system:

(a) Connect 2" discharge hose from vent vessel outlet on ROWPU to the drainage area.

(b) Connect 2" discharge hose from waste water outlet on ROWPU to the drainage area.

(13) Recheck all hose connections to ensure they are tight.

(14) Install chemical feed system:

(a) Hoses are stored attached to pump.

(b) Install quick-disconnect end of hoses to each 5 gallon container.

(c) Ensure both suction and return hoses are sealed tight and to the proper container.

(d) Set chemical feed pump valves to "Prime".

(15) Ground the ROWPU with the grounding rod.

(16) Hook up the power cable to the ROWPU.

(a) If the motors to the pumps run in reverse, change two of the hot leads from one stud to another: L1 - L2 or L3.

(b) If wire is not marked with industrial tags, a continuity check will be necessary to correctly connect the unit.

(17) Ensure power is off until the unit is completely set up for operation.

c. Preposition valves and switches:

(1) Turn off all breakers.

(2) Open vent valves:

(a) Vent cartridge filter valve.

(b) Vent pulse dampener valve.

(c) Vent multimedia filter valve.

(3) Set backwash valve to normal.

(4) Push in emergency stop button.

(5) Set all control box switches to STOP or OFF.

(6) Open regulate product flow valve.

(7) Open vent vessels valve.

(8) Set element cleaning switch to off.

(9) Set backwash timer knob to "Service" position.

(10) Mix the following chemical solutions in separate 3 gallon pails using best available water; brine or raw water. Ensure that water being used contains no chlorine.

(a) Calcium Hypochlorite - .2 lbs

(b) Polyelectrolyte - 53 ml

(c) Sodium Hexametaphosphate - .1 lbs

(d) Citric Acid - .75 lbs

(e) Stir solutions for at least 1 min. using wooden paddles and pour into 5 gal containers marked with their respective chemical label.

**NOTE: Do use chemical pails and wooden paddles for jobs other than those intended.**

- (11) Turn chemical valves to prime position.
- (12) Open product water vent valve.
- (13) Close product water drain cock. Found only on the "Alpha" model.
- (14) Close seven drains in the rear of the unit.
- (15) Close eight product water sample valves. Found only on the "Bravo" and "Charlie" models.

d. Perform before operation checks and services:

(1) Check oil levels:

(a) R.O. pump: Oil level should be at least half to 3/4 way up on sight glass. R.O. pump holds 2 gals of OE/HDO-40 or OE/HDO-30 non-detergent oil, which is changed by the following intervals:

- 1 Changed before first operation
- 2 After the first six weeks of operation
- 3 Every 3 months or 1,000 hrs. of operation

(b) Chemical feed pump: Oil level should be to the middle of the sight glass on the "Alpha" model. The "Bravo" and "Charlie" models have a dip stick. Chemical feed pump holds 1 pt. of 85w-140 gear oil (with rust inhibitor).

- 1 Oil is checked weekly.
- 2 Oil is changed every 4,000 hours of operation or each year.

(2) Perform visual inspection:

(a) General: Inspect the general appearance and possible damage of the unit and all its accessories.

(b) Filters: Check for loose connections and leaking gaskets.

(c) Gauges and Indicators: Inspect for broken glass and loose mountings. Check for salt residue inside the gauges.

(d) Pumps: Check for possible damage, damaged fittings, inspect drive belts on R.O. pump.

4. Start up procedures:

- a. Start generator and apply power load to ROWPU.
- b. Turn on circuit breakers.
- c. Pull out emergency stop button.

**NOTE: When emergency stop button activates the R.O. pump low pressure lamp will light.**

- d. Jog R.O. pump to ensure motor is running in proper direction.

e. Prime raw water pump:

- (1) Make sure the drain valves are closed.
- (2) Prime the pump through the priming port.

f. Start raw water pump:

- (1) Ensure the motor is running clockwise.
- (2) Set switch upward to START.
- (3) Hold switch up until green lamp comes on, ensure that pump starts.
- (4) Release the switch.
- (5) Switch will return to RUN.
- (6) Look at raw water input hose, if pump is drawing water, the hose will pulsate and fill with water.
- (7) The raw water flow rate will jump from 0 to 40 gpm and then gradually drop down to between 27 and 33 gpm flow.

- g. Turn on chemical feed pump.

h. Prime polymer chemical feed pump:

- (1) Set polymer chemical feed control knob to 5.

**NOTE: Adjust controls of chemical feed pumps only while motor is running.**

- (2) Allow pump to run on prime until no more air bubbles are seen in the return line.

**NOTE: If pump fails to prime, set control knob to 8.5. Pump will pick up the prime in a few seconds. Return control knob to 5.**

i. Calibrate the polymer:

- (1) Set control knob to 1.5 (On "Alpha" models, set to 2.6)
- (2) Obtain your 100 ml graduated plastic cylinder.
- (3) While the polymer pump is running, disconnect the polymer return line, use the 100 ml cylinder and time the flow for 1 minute.
- (4) Flow should be 60 ml. If not, adjust the control knob setting until you get a 60 ml per minute flow.
- (5) Record the knob setting.

j. With raw water pump working and the chemical feed pump running, set the polymer pump valve from PRIME to RUN.

k. Go around to the control panel.

l. Close vent multimedia filter valve as soon as a full stream of water flows out of vent pipe (located at the bottom right-hand front of the unit, below R.O. pump belt guard).

m. Start booster pump.

n. Close vent cartridge filter valve as soon as a full stream of water flows out of vent pipe.

o. Reset R.O. pump:

- (1) Set R.O. pump reset switch upward to RESET.
- (2) Release switch.
- (3) Yellow R.O. pump low pressure lamp goes off.
- (4) Switch returns to ON.

p. Start R.O. pump.

**NOTE: R.O. pump will not start unless it is reset.**

q. Observe R.O. pump:

- (1) Make sure the R.O. pump is running smoothly.
- (2) Make sure the belts are not slapping.

r. Close vent pulse dampener valve as soon as you see a full stream of water coming from the vent pipe.

s. At this time, due to the lack of pressure, the semi-filtered water is backed up at the R.O. vessels and exiting the ROWPU through the vent vessel line.

t. Observe vent vessel hose for clarity. Within approximately 10 minutes the water should be clear.

u. While waiting, prime and calibrate the chlorine and sodium hex chemical pumps just like the polymer chemical pump.

v. Set citric acid pump knob to 8.5, which is the max setting, and leave it on prime.

w. After calibrating sodium hex and chlorine pumps, set sodium hex valve to RUN and leave chlorine on PRIME.

x. Perform a turbidity test of the water once the vent vessel water has cleared up:

(1) Obtain the 1000 ml graduate cylinder with the white bulls-eye set in a black background on the bottom of the tube.

(2) Draw a sample of 600 ml of water from drain NO. 1 cartridge filter into the turbidity tube.

(3) Look down into the turbidity tube and you should be able to see both the white bulls-eye and the black disc at the bottom of the tube clearly.

(4) If both cannot be seen clearly (water is chalky), run the ROWPU another 10 minutes. Repeat the sampling test.

(5) If after second sampling test, water is not clear, readjust polymer chemical feed control knob setting down in .5 measurements.

(6) Wait 5 minutes then examine another sample of water.

(7) If water is still not clear, repeat this process and keep reducing the chemical setting by .5 each time and waiting 5 minutes until the water is clear.

**NOTE: Obtaining a clear sample of water means that you have the right amount of polymer mixed with raw water for better filtration.**

y. **Slowly** close vent vessels valve. This closes off the water's path of least resistance and allows filtered water to enter R.O. vessels.

z. **Slowly** adjust regulate product flow valve clock-wise:

(1) Watch for rise on product water flow gauge.

(2) Watch for decrease on brine flow gauge.



(3) Watch for rising pressure on R.O. pressure PSI gauge.

(4) Stop turning the valve when the 1st extreme has been met.

**NOTE:** Normally, product water flow should not exceed 16 gpm. R.O. pressure psi gauge should not be above 960 psi.

**NOTE:** Close regulate product flow valve very slowly. Sudden high pressure to the R.O. vessels could damage the R.O. elements.

aa. Set chlorine valve to RUN position.

bb. Close vent product water valve.

5. Perform during operation checks and services.

a. Listen for unusual noises and look for any leaks.

b. Monitor all gauges.

c. Record gauge readings each hour and log it in operators log.

GAUGE/INDICATOR	NORMAL READINGS	TROUBLE POINT READING
Raw Water Flow	27-33 GPM	Below 25 GPM
Multimedia Filter	0-10 PSID	Over 10 PSID
Cartridge Filter	1-20 PSID	Over 20 PSID
Brine Flow	16-24 GPM	Below 15 GPM
<b>R.O. Pressure PSI</b>		
Fresh Water	500 PSI	Above 500 PSID
Brackish Water	500 PSI	Above 500 PSID
Salt Water	960 PSI	Above 960 PSID
<b>Product Water Flow</b>		
Fresh Water	Up to 16 GPM	Above 16 GPM
Brackish Water	Up to 16 GPM	Above 16 GPM
Salt Water	6-12 GPM	Above 12 GPM
R.O. Vessels	50-100 PSID	Over 100 PSID
Product Water TDS	Below 1500 TDS	Above 1500 TDS
Product Water Chlorine	1.0-2.0 ppm (5.0 for storage)	Below 1.0 ppm (below 5.0 for storage)
Brine Water pH	Below 8.0	Above 8.0 Ph

d. Obtain chlorine residual reading of product water from product water hose. If too high or low, adjust setting on chlorine chemical feed pump.

e. Take a TDS reading of product water.

f. Take a pH of brine water from brine hose. If pH is above 8.0, a citric acid feed is necessary to lower pH between 5.0 - 8.0.

NOTE: The R.O. membranes operate best in water containing a pH of 5.5. For example: water with a pH of 5.5 might produce 500 ppm TDS product water, whereas the same water with a pH of 7.5 might produce a product water with 1000-1500 ppm TDS. Due to the cost of citric acid, it is recommended to use citric acid only after each 20 hours of operation.

(1) Perform Citric Acid Feed:

- (a) Set citric acid feed pump valve on RUN.
- (b) Wait until 5 gal container is empty.
- (c) Draw a sample from the brine hose and check pH reading.
- (d) If reading is above 8, feed a new batch of citric acid with 1-1/2 pounds of citric acid with 3 gallons of brine water.
- (e) When reading drops below 8.0, the following must be done:

1 Set citric acid chemical feed pump valve back to PRIME.

2 Place product water hose in product water tank.

6. Daily water production log (DA Form 1713-R):

a. General: Logs are important because the information from these forms are used to schedule resupply of chemicals, POL, and maintenance of the equipment. The following is a guidance on completing the DA Form 1713-R.

b. Hourly chemical dosage log:

- (1) Shift Number: - Enter the shift hours on this block.
- (2) Water Point Number/ROWPU Number: Enter the assigned water point number and ROWPU serial number.
- (3) NCO in Charge: - Enter the name of the NCO supervising the water point.
- (4) Date: Write out the date at the start of each new day.
- (5) Time: Enter the time the ROWPU was started and stopped. Also log the time the ROWPU is shut down for maintenance.
- (6) Citric Acid, Sodium Hex, Chlorine, and Polymer: Enter the initial knob setting and amount of chemicals used for the initial charge. Make a separate log entry every time you recharge.

(7) pH: Enter the initial pH reading of the raw water and the pH from the product water.

(8) Chlorine residual: Enter the residual reading taken from the product water after at least 30 minutes contact time.

(9) Remarks: Enter the reason that the production was halted (for example, backwashing, R.O. element cleaning, cartridge filter replacement). Also note any significant event that may affect water point operations.

(10) Chemicals Used: Enter the total amount of each chemical used for the shift. Start a new form for each shift.

(11) Chemicals on Hand: Enter the total amount of chemicals you have on hand for this ROWPU at the end of the shift.

c. Gauge and indicator log:

(1) Time: Enter the time you started the ROWPU and the time it was shut down.

(2) Product Water Flow: Enter the reading from the product water flow gauge on the ROWPU.

(3) Reverse Osmosis Pressure: Enter the reading from the R.O. pressure PSI gauge.

(4) Cartridge Filter: Enter the pressure differential reading from the cartridge filter gauge.

(5) Multimedia Filter: Enter the pressure differential reading from the multimedia filter gauge.

(6) Raw Water Flow: Enter the reading from the raw water flow gauge.

(7) Brine Flow: Enter the reading from the brine flow gauge.

(8) Reverse Osmosis Vessels: Enter the pressure differential reading from the R.O. vessels gauge.

(9) Total Dissolved Solids: Enter the TDS reading.

(10) Remarks: Enter the reason that the production was halted (for example, backwashing, R.O. element cleaning, cartridge filter replacement). Also note any significant event that may affect water point operations.

(11) Total Hours Operated: Enter the total amount of hours the unit was operated during the shift.

(12) POL Used: Enter the total amount of each POL used for the shift. Start a new form for each shift.

(13) POL on Hand: Enter the total amount of POL you have on hand for this ROWPU at the end of the shift.

7. Shutdown procedures:

a. Normal shutdown:

(1) Remove product water hose from product water tank and set the hose in the drainage area.

(2) Set all chemical pump valves to prime and wait 2 minutes for chlorine to exit the product water outlet.

(3) Open regulate product flow valve slowly.

(4) Wait 5 minutes before opening the vent vessels valve.

(5) Open four vent valves:

(a) Vent cartridge filter valve.

(b) Vent pulse damper valve.

(c) Vent multimedia filter valve.

(d) Vent product water valve.

(6) Place Reverse Osmosis pump switch down to STOP (yellow low pressure lamp will come on).

(7) Place booster pump switch down to STOP.

(8) Place chemical feed pump switch down to STOP.

(9) Place raw water pump switch down to STOP.

(10) Push in emergency stop button.

(11) Turn off circuit breakers.

(12) Turn off generator.

**NOTE: If unit will not be operated within 12 hours, open the seven drains and drain the unit.**

b. Long shutdown:

**NOTE: Long shutdowns will be completed at the end of operations.**

(1) Shut down ROWPU normally.

(2) Backwash the multimedia filter

- (3) Perform R.O. element cleaning.
- (4) Remove the strainer and hose from water source.
- (5) Drain ROWPU pipes, filters and connections:
  - (a) Open seven drain valves.
  - (b) Open four vent valves.
- (6) Drain R.O. pump.
- (7) Drain booster pump.
- (8) Drain chemical feed pumps.
- (9) Drain raw water pumps #1 and #2.
- (10) Drain distribution pump.
- (11) Shut off all electrical power.
- (12) Disconnect all hoses and pumps from ROWPU.
- (13) Roll up all hoses and power cables.
- (14) Repack all components of ROWPU.

8. Perform after operation checks and services:

a. General: Inspect general appearance of the unit. Inspect for water leaks, loose or missing bolts, screws, nuts, and hoses. Inspect for signs of damage and loose or broken cable connections.

b. Frame and Equipment: Remove oil, grease, mud, chemical spills, and other matter from all parts of Reverse Osmosis Water Purification Unit.

c. Multimedia and Cartridge Filters: Inspect for leaks and loose connections and mountings.

d. Gauges and Flow Indicators: Inspect for broken glass and look for loose mountings and tube connections.

e. Chemical Feed Pump: Inspect for loose mounting nuts. Inspect for cracked or broken fittings. Check oil level and condition of oil.

f. Reverse Osmosis Pump: Check all five V-belts for cracks, rubbing and signs of wear. Check belt tension. Check oil level and condition.

9. Installation of nuclear, biological, and chemical cartridges:

a. The ROWPU has overpack items which are used as a post-treatment when nuclear or chemical contaminants are present. The equipment consists of a cartridge to remove nuclear contaminants, a cartridge used to remove chemical contaminants, and the adapters, bushings, clamps, couplings, reducers, and tubing needed for assembly.

**WARNING: RADIOACTIVE CONTAMINANTS ARE POTENTIALLY HAZARDOUS. USE EXTREME CARE IN REPLACING CARTRIDGES AND FOLLOW SAFETY PROCEDURES IN THEIR HANDLING AND DISPOSAL.**

**NOTE: Do not operate chlorination feed pump during NBC cartridges operation.**

b. For nuclear, biological or chemical contamination, use both the cartridge marked "FOR USE WITH RADIOACTIVE CONTAMINATED WATER ONLY" and the cartridge marked "FOR USE WITH CHEMICALLY CONTAMINATED WATER ONLY."

c. Exchange the inlet and outlet raw water pump adapter which is used in the NBC system and prepare to assemble NBC filters between two raw water tanks.

d. Use one of the raw water pumps to force the water through the NBC cartridges.

e. Install raw water pump:

(1) Install 1-1/2 inch suction hose from raw water tank and swivel adapter on raw water pump.

(2) Attach female end of distribution (suction or discharge) hose to straight adapter on raw water pump.

(3) Attach swivel adapter to gate valve and attach male end of distribution hose to swivel adapter.

(4) Attach shoulder bushing and adapter to gate valve.

**NOTE: The NBC cartridges should be positioned so that the cartridge marked "FOR USE WITH CHEMICALLY CONTAMINATED WATER ONLY" is first in the series. Position the cartridge marked "FOR USE WITH RADIOACTIVE CONTAMINATED WATER" so that water is filtered through this cartridge**

f. Assemble the NBC cartridge in series.

**NOTE: Pay special attention to the input and output labels on top of the NBC cartridges when connecting the 3/4 inch reinforced flexible tubing to the cartridges.**

**NOTE: Do not operate chlorination feed pump during NBC operation.**

- (1) Slide clamp over end of one section of 3/4 inch x 80 inch flexible tubing. Attach tubing to adapter on gate valve and close clamp.
- (2) Slide clamp over other end of tubing.
- (3) Remove plug from INLET port on FOR USE WITH CHEMICALLY CONTAMINATED WATER cartridge and insert adapter.
- (4) Attach tubing to adapter on INLET port and close clamp.
- (5) Cut one section of 3/4 inch x 80 inch flexible tubing to a maximum length of 24 inches.
- (6) Slide clamp over end of tubing.
- (7) Remove plug from OUTLET port on FOR USE WITH CHEMICALLY CONTAMINATED WATER cartridge and insert adapter into cartridge.
- (8) Attach tubing to adapter on OUTLET port and close clamp.
- (9) Remove plug from INLET port on FOR USE WITH RADIOACTIVE CONTAMINATED WATER cartridge and insert adapter in cartridge.
- (10) Slide clamp over end of tubing.
- (11) Attach tubing to adapter on INLET port and close clamp.
- (12) Slide clamp over end of second section of 3/4 inch x 80 inch flexible tubing.
- (13) Remove plug from OUTLET port on FOR USE WITH RADIOACTIVE CONTAMINATED WATER cartridge and insert adapter.
- (14) Attach tubing to adapter on OUTLET port and close clamp.

g. Complete connection of NBC cartridge to second raw water tank.

- (1) Slide clamp over remaining end of 3/4 inch x 80 inch flexible tubing.
- (2) Insert adapter into tubing and close clamp.
- (3) Attach shoulder bushing, pipe coupling, and straight adapter to 1-1/2 inch discharge hose and connect to second raw water tank.

h. During NBC operation, it is necessary to chlorinate the second tank by hand.

i. With the exception of the chlorination feed pump, operate the ROWPU using normal operating procedures.

- j. Change the cartridges after every 100 hours of operating time.

10. Backwash of the multimedia filter:

a. Reason for backwash: To remove any dirt and solid material caught inside multimedia filter layers. During the backwash cycle the water from the backwash tank is pumped by the backwash pump through the multimedia filter layers in reverse (from bottom to top) and any dirt and solid materials are washed out from the filter media.

b. When to backwash: The multimedia filter should be backwashed:

- (1) Every 20 hours of operation.
- (2) Multimedia filter gauge rises 5 psid above the initial reading.
- (3) When R.O. unit will not be operated for more than 12 hours.
- (4) Before movement.

c. Performing backwash:

- (1) Shut down the R.O. unit normally (short shutdown).
- (2) Check water level in backwash tank. Ensure you have at least 1500 gallons of water in the backwash tank.
- (3) Open the 2" gate valve attached to the backwash tank.
- (4) Prime backwash pump. (Clean backwash pump strainer.)
- (5) Turn backwash valve handle down to "backwash".
- (6) Set START backwash switch up and release immediately.
- (7) Backwash pump and backwash cycle should start within 2 to 3 seconds. The cycle is started when the white lamp comes on, and is ended when the backwash pump stops and white lamp goes OFF. The complete backwash cycle lasts about 13 minutes.

**NOTE:** During backwash cycle, make sure the backwash tank does not go dry before the backwash cycle is completed. The proper reading on the backwash gauge is 0, 70, or 120, depending on which cycle of backwash the unit is in.

- (8) When backwash is completed and the white lamp goes off, turn backwash valve handle to normal.



(9) Close the gate valve on the backwash tank valve.

(10) Start the R.O. unit normally.

**CAUTION: BACKWASH SHOULD NEVER BE PERFORMED IF THE R.O. UNIT MULTIMEDIA FILTER IS DRAINED OR PARTIALLY DRAINED. IF SO, OPERATE THE R.O. UNIT NORMALLY FOR AT LEAST 30 MINUTES NONSTOP TO PRIME THE FILTER AND TO REMOVE ALL AIR FROM INSIDE THE FILTER.**

11. R.O. Element cleaning:

a. It will be necessary to clean the R.O. elements to improve total dissolved solids (TDS) rejection, and reduce operating pressure (RO pressure PSI). Two methods of cleaning elements are available. One method, which is used more often, is to flush citric acid solution through the vessels. The second method is to flush a Triton X cleaning solution through the R.O. vessels. These solutions remove unwanted material from the membranes.

b. Conditions requiring element cleaning:

(1) Whenever the pressure in the R.O. vessels shown on the R.O. pressure PSI indicator rises to either 960 for seawater or 500 for fresh water, and at the same time the product water flow gauge drops below minimum reading (6 GPM).

(2) Whenever product water output drops several gallons per minute on product water flow indicator with no change in raw water temperature. The unit operates better in warmer weather than in colder, ideal is 74°F.

(3) Whenever brine flow increases noticeably and adjustment regulate product flow valve does not correct the product water flow indication.

(4) When R.O. vessel pressure increases by 20% over the initial reading.

c. R.O. Element Cleaning Procedure:

(1) Perform a normal shutdown.

(2) Backwash multimedia filter.

(3) After the completion of backwash, water level in backwash tank should be 7 inches. Check for a 7 inch brine water level, with telescoping aluminum mixing paddle.

(4) Adjust the pH of backwash water between 3.5 - 4.0 by adding .75 lbs. of citric acid and stir until all granules are dissolved. If needed, add more until pH is correct.

**NOTE: The pH of water must not be lower than 3.5. If lower, add brine water to raise the pH.**

(5) Remove the hose from the backwash inlet on the control panel and connect it to the Vent Vessels line. The vent vessel hose can be placed on the ground until normal operation is continued.

(6) Open the 2" gate valve on the bottom of the backwash tank.

(7) Push element cleaning switch up to START position.

(8) Brine flow indicator should show a flow of 16 gpm or more.

(9) Every 5 minutes, check pH of the water discharging back into the backwash tank. The water should read near but not below a pH of 3.5. If it isn't, add 1 pound of citric acid at 5 minute intervals until it is.

(10) Allow citric acid solution to flow for 45 minutes or until the temperature of the water reaches 120 degrees F. Temperature of water can be checked by using thermometer in SL-3 storage box.

(11) Push the element cleaning switch down to OFF.

(12) Reconnect hoses on unit for normal operation.

(13) Drain the citric acid solution into a shallow, man-made lagoon, a reasonable distance away from the unit.

(14) Perform start-up procedures for normal operation.

(15) Allow ROWPU to operate for 10 min. to rinse the R.O. vessels.

(16) Perform operational adjustments.

(17) Take a pH of the brine water. If pH is below 8.0, continue to operate unit and document all gauge readings.

**NOTE: If the regulate product flow valve adjustment will not give a proper product water flow indicator reading after 2 hours of operation, shut down the ROWPU normally.**

(18) Flush out the ROWPU with 800 ml of Triton X Detergent to 1500 gal. of backwash water.

## 12. R.O. element replacement:

### a. Pre-removal Procedures:

(1) Shut the ROWPU down normally.

(2) Open all vents, drains, and controls.

(3) Mark the end caps and vessel alignment marks, to insure that end caps are installed in the same position to reduce chances of leaks.

b. End Cap Removal:

(1) Open quick disconnect and pull out tube.

(2) Remove nut, screw, clamp, and coupling.

(3) Loosen nut on elbow and swing elbow away from the end cap.

(4) Remove end cap nuts and washers from the end cap.

**CAUTION: DO NOT ATTEMPT TO PRY END CAP FROM VESSEL. THIS COULD DAMAGE THE SEAL.**

(5) Screw two end cap puller bolts (1/4 - 20 x 20 in.) into threaded holes in the end cap.

(6) Alternately rotate each bolt one complete turn until end cap and O-ring are separated from the R.O. pressure tube. Remove end cap and O-ring.

(7) Repeat this procedure to remove the rear end cap.

c. Removal of R.O. Elements:

(1) Assemble element puller:

(a) Connect together the puller rod and puller rod handle.

(b) Insert elements puller into R.O. vessel. Push puller through end connector, through the product water tubes of the two R.O. elements, and through the interconnector between the two R.O. elements.

(c) Place element puller plate on assembled element puller and secure with flat washer and nut.

(2) Slowly pull both R.O. elements from R.O. vessel, being careful to keep element puller centered in tube. Make sure you are removing with the flow of water.

(3) Disconnect the element puller after both elements are removed.

(4) Separate R.O. elements by removing R.O. element interconnector.

**CAUTION: WHEN REMOVING R.O. ELEMENTS FROM R.O. VESSEL, MAKE SURE YOU REMOVE THEM FROM THE OPPOSITE END OF INSTALLATION (ALWAYS WITH THE DIRECTION OF FLOW).**

**NOTE: It requires at least two people when removing the elements. One to pull on the element puller assembly and one to hold the elements as they come out.**

d. Installation of R.O. Elements:

(1) Lubricate O-rings with glycerin, lightly.

(2) Install O-rings and end connectors.

**WARNING: R.O. ELEMENTS ARE PACKAGED IN SEALED PLASTIC BAGS WITH A PROTECTIVE CHEMICAL CALLED FORMALDEHYDE WHICH IS POISONOUS; AVOID FUMES AND KEEP AWAY FROM EYES AND MOUTH. HANDLE WITH EXTREME CARE. AFTER HANDLING, WASH HANDS THOROUGHLY WITH SOAP AND WATER.**

**CAUTION: AFTER REMOVING R.O. ELEMENT FROM SEALED PLASTIC BAG, KEEP ELEMENTS CLEAN. FAILURE TO DO SO WILL CAN AND WILL CAUSE EARLY ELEMENT FAILURE.**

(3) Remove new R.O. element from sealed plastic bag.

(4) Lubricate brine seal with glycerin.

(5) Install brine seal in groove of R.O. element, making sure open tip of the seal faces the end of element closest to the groove.

(6) Insert by hand the first R.O. element into R.O. vessel until brine seal touches end of R.O. vessel. Make sure you insert the elements with the flow of water.

**NOTE: In the "Alpha" model, flow of water differs from the other models.**

**CAUTION: WHEN INSERTING R.O. ELEMENTS INTO R.O. VESSEL, MAKE SURE THAT THE END OF THE ELEMENT, WITHOUT THE BRINE SEAL, GOES IN FIRST, ON THE FRONT SIDE OF THE R.O. VESSEL (WITH DIRECTION OF FLOW).**

(7) Place interconnector on product water tube of first R.O. element.

(8) Remove second R.O. element from sealed plastic bag.

(9) Lubricate and install brine seal.

(10) Insert product water tube of the second R.O. element into interconnector.

- R.O. (11) Slide both R.O. elements and interconnector into the vessel until they are centered in the vessel.
- (12) Place end connectors on both ends of product water tubes of R.O. elements.
- (13) Lubricate and install end cap O-rings and end caps.
- (14) Align end caps with match mark on R.O. vessel.
- (15) Press end caps into studs and install ten washers and nuts onto studs. Maximum torque for end caps is 65 in./lbs. This is equivalent to about 5.4ft/lbs.
- (16) Reconnect tubes and pipes to R.O. vessel.

**NOTE: During operation observe for leaks.**

13. Changing the cartridge filters:

a. Removal of cartridge filters:

- (1) Remove vent line from elbow.

**NOTE: The cover is installed under tension by loosening eye nuts in a few turns at a time in an alternating pattern.**

- (2) Loosen six eye nuts and rotate assembly out of notches in cover, remove cover with attached part.

- (3) Position cover handle down.
- (4) Remove eight top seat cups and spring.
- (5) Remove the o-ring.
- (6) Remove locknut from bolt.
- (7) Remove and discard eight filter tubes.

b. Inspection of the cartridge filter assembly:

- (1) Inspect eyebolts for cracks, damaged threads, bent shafts, or deformed eyes. Replace as required.
- (2) Inspect o-ring for cracks, dry rot. Replace as required.
- (3) Inspect elbow on the cover for cracks.
- (4) Inspect bottom seat cups for deformity or looseness.

c. Installation of new cartridge filters:

- (1) Replace eight filter tubes with male plastic end being inserted first to form a tight seal.
- (2) Install eyebolt, washer, and eyenut.
- (3) Install bolt and locknut.
- (4) Relube and install o-ring.
- (5) Install eight seat cups and springs.
- (6) Install cover with attached parts and tighten six eye nuts.
- (7) Install vent line.

**NOTE:** During the initial shipment of the unit from the factory, the cartridge filter tube elements are shipped outside the filter unit.

REFERENCES:

TM-08580A-10/1  
TM-08580B-10/1  
TM-08580C-10/1  
TM-4700-15/1  
FM-10-52-1